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Groundwater Governance and the Construction of Legal Indicators for Brazilian States

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Abstract: The 1988 Brazilian Federal Constitution granted a leading role in groundwater governance to the states and the Federal District. However, there are no studies evaluating how these entities conducted this process from a national public policy perspective. The present article aims to identify national legal obligations related to groundwater governance and develop a tool to determine whether the states have appropriately implemented them. Our methodology includes document analysis and interviews. The federal legislation provided standard mechanisms for state management, allowing for structuring a Groundwater Governance Assessment System (SAGAS: the acronym in Portuguese) that comprises 48 primary and 25 secondary indicators. SAGAS is a methodological effort to create a legal indicator to generate comparable and systematized data on states' environment of governance to help identify management weaknesses.

Keywords: Groundwater governance; legal indicators; federal legislation; Brazilian states

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Introduction

Groundwater is essential to national water security and ecosystems. However, few studies aim to assess whether groundwater was included in public policies or how these processes may have occurred (FERNANDES, 2019). The 1998 Brazilian Federal Constitution (FC/88) has granted the domain of the states over groundwaters (art. 26, I), and provided them concurrent (art. 24), residual (art. 25, § 1º), supplementary (art. 24, § 2º), and shared (art. 23, VI) competencies (FERNANDES, 2019; VILLAR; GRANZIERA, 2020). As a result, the states and the Federal District are the leading entities managing groundwater, even when those waters cross state and national borders[1]. These management processes must comply with national policies because the Federal Government holds the privative competence to legislate about Water Law (art. 22, IV, of FC/88) (FERNANDES, 2019; VILLAR; GRANZIERA, 2020). In addition, states must seek ways to incorporate municipalities in water management because they possess the competence to promote soil use and territorial planning (art. 30, VIII, of the FC/88) (SOUZA, 2012).

The states and the Federal District set the institutional infrastructure of the State Water Resources Management Systems, and state policies focus on their water resources and on implementing water management instruments (FERNANDES, 2019). However, studies on the existence of a favorable environment for groundwater governance at the state level are lacking (CONICELLI; HIRATA, 2017; OSPINA, 2018; FERNANDES, 2019).

The Organization for Economic Cooperation and Development - OECD (2018) highlighted the gaps in water governance in Brazil and the need for improvements. That study highlighted the lack of coordination between states and the federal government, the limitations of the institutional framework, and the application of management instruments; however, it did not examine how these factors play out in the states, primarily relating to groundwater.

It remains a challenge to develop an instrument to assess water resource governance; there are difficulties in defining that governance and determining its features, properties, and targets (WOODHOUSE; MULLER, 2017). The particularities of groundwater complicate the task due to its social invisibility and the prevalence of Earth and Engineering Science approaches (ZAGONARI, 2010). The development of groundwater indicators and their analysis have focused on hydrogeological data such as water quality and the presence of contaminants, water quantity, rates of groundwater use, aquifer recharge or well productivity, and aquifer vulnerability and their interactions with ecosystems (VRBA; LIPPONEN, 2007; HIRATA; SUHOGUSOFF; FERNANDES, 2007; PEREZ et al., 2015; KORBEL; HOSE, 2017). These indicators prioritize evaluating aquifer conditions rather than the political, institutional, and legal environment charged with their governance. Apart from Earth and Engineering Sciences studies, there are few studies of how Brazilian states carry out governance; instead, the literature focuses

1 - The current study does not intend to discuss groundwater competence matters, as several authors have already addressed this topic (CAMARGO; RIBEIRO, 2009; FERNANDES, 2019; VILLAR; GRANZIERA, 2020).

on the transboundary aspects of governance, particularly related to the Guarani Aquifer (SANTOS; RIBEIRO, 2016).

Bohn, Goetten, and Primo (2014), Goetten (2015) and Ramos (2017) performed preliminary assessments of the governance environment in the states of Rio Grande do Sul, Santa Catarina, Paraná, Minas Gerais, Mato Grosso, Mato Grosso do Sul, and Goiás, based on the checklist proposed by Foster et al. (2009). Fernandes and Oliveira (2018abcd) gathered all groundwater legislation in the Southeastern, Northern, Southern, and Midwestern regions. Fernandes (2019) published an article providing an overview of states' legislation, and Ospina (2018) developed a set of principles and descriptors that intended to identify indicators to assess local groundwater management processes.

The following questions have arisen: a) how can one assess state governance of groundwater given the lack of references to the several states' situations? and b) what are the criteria to be met to objectively assess and compare these institutional, political, and legal environments? In response, we developed the hypothesis that a favorable environment for state groundwater governance should, at least, embody and implement obligations provided on the national legislation.

Accordingly, this article aims to identify the national legal obligations related to groundwater governance and develop a tool to determine whether such obligations were suitably embodied and implemented by the several states. The use of law as a parameter to build indicators is justified because it establishes the "structure, limits, rules, and processes where the governmental action takes place" (COSENS et al., 2017, p. 1). In addition, it plays a crucial role in water governance because it regulates state conduct and the actions of society and private agents (COSENS et al., 2017). The study followed the documentary analysis of both the literature and the federal legislation for its methodology and conducted semi-structured interviews with experts. The article is divided into four sections: the first contextualizes the discussion about groundwater governance and the role of legal provisions in it; the second section justifies the creation of legal indicators to assess the governance environment; the third section introduces the tool called the Groundwater Governance Evaluation System, also known as SAGAS (the acronym in Portuguese); the last section offers final considerations.

Groundwater governance and the role of law

The discussion regarding water governance is marked by several concepts (WOODHOUSE; MULLER, 2017; HAVEKES *et al.*, 2016; LAUTZE *et al.*, 2011) and approaches such as adaptive governance, adaptive capacity, social learning, Integrated Water Resources Management, community-based natural resource management, multi-level governance, polycentric governance, trialogue governance, the water-food-energy nexus, effective governance, and shared resources, among others (RIBEIRO; JOHNSSON, 2018). However, there is no consensus regarding the concept of water governance; overall, the meaning of this expression includes the sense of processes, institutions, and actors involved in decision-making concerning the use of water resources (LAUTZE *et al.*, 2011). Therefore, groundwater governance is herein understood as "the overarching framework

of groundwater use laws, regulations, and customs, as well as the processes of engaging the public sector, the private sector, and civil society" (MEGDAL *et al.*, 2015, p. 678).

The literature highlights the relevance of joint water governance (KORBEL; HOSE, 2017; MOLLE; LÓPEZ-GUNN; VAN STEENBERGEN, 2018). However, public policies did not pay adequate attention to groundwater, and this gap is known in the literature as "hydro-schizophrenia" (JARVIS *et al.*, 2005). This phenomenon is explained by the following factors: a) the social invisibility of groundwater; b) the lack of knowledge about aquifer function; c) the cultural perception that groundwater is bonded to soil property rights; d) the ease and convenience of drilling wells; e) groundwater is a common pool resource; f) the difficulties in inspecting wells; and e) the lack of popular pressure over groundwater management (JARVIS *et al.*, 2005; MADANI; DINAR, 2012; VILLAR, 2016). The sense of "hydro-schizophrenia" is not limited to prioritizing surface water over groundwater; the water management process also faces difficulties regarding elements that compose the water cycle, such as meteoric and atmospheric water and forest evapotranspiration.

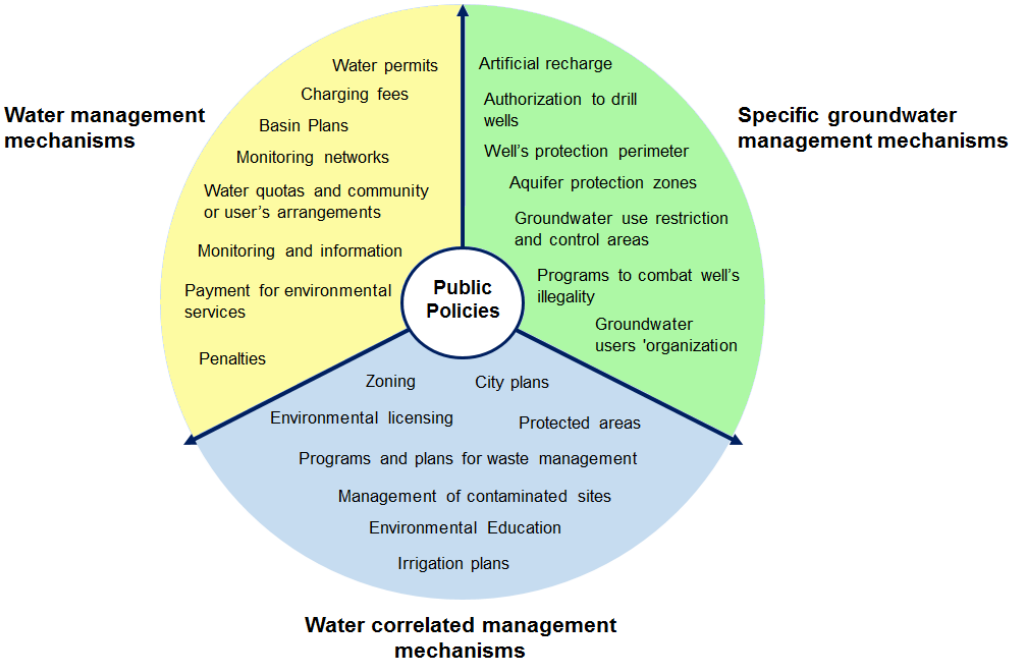
Accordingly, from 2005 on, we note the appearance of several studies regarding groundwater governance (MOLLE; LÓPEZ-GUNN; VAN STEENBERGEN, 2018). For example, Food and Agricultural Organization - FAO (2016, p. 13) divided governance into four components: a) "an effective and articulated legal and regulatory framework"; b) accurate and shared knowledge about aquifer systems and social awareness; c) an institutional framework featured by leadership, solid and qualified organizations, permanent involvement of social actors, and working mechanisms to coordinate groundwater with other sectors; and d) "policies, plans, finances and incentive structures aligned with society goals."

The law holds conceptual and operational importance in governance (GARBACCIO; PRIEUR; DENNY, 2018) because laws, regulations, and customs dictate how groundwater is managed and used (MEGDAL *et al.*, 2015). If a law is combined with political action, it can represent an instrument of commitment and political coordination with the following aims: a) ensuring management legitimacy, participation, morality, transparency, and equity; b) promoting equity of distribution of water resource benefits and onus; c) creating spaces to mediate conflicts; d) establishing mandatory studies to substantiate decision-making processes; e) encouraging participation and social control in public policies and decision-making processes; f) encouraging behaviors dedicated to promoting sustainability; g) discouraging conduct that degrades the environment or promotes the irrational use of resources; h) managing societal expectations toward water resource use and the environment; i) drawing users and societal rights and obligations concerning the environment; and j) setting the conditions for environmental liability and the applicable sanctions (WORLD BANK, 2017).

How laws, regulations, and customs are established reproduces the result of "many viewpoints, values, knowledge systems, information types, and power struggles" (COSENS *et al.*, 2017, p. 1). Therefore, the development and implementation of law reflect a continuous process of governance (GARBACCIO; PRIEUR; DENNY, 2018). Figure 1

illustrates the primary mechanisms dedicated to protecting groundwater found in the international literature and related to the legal activity. These instruments are divided into those focused on water management, specific mechanisms to manage groundwater, and correlated mechanisms (MOLLE; LÓPEZ-GUNN; VAN STEENBERGEN, 2018). The literature and managers pointed out that lack of laws and regulations have been a barrier; however, the principal issue is the lack of law implementation and fulfillment (MOLE; CLOSAS, 2019).

Figure 1 – Direct and indirect groundwater management mechanisms



SOURCE: Megdal et al. (2015); World Bank (2017); FAO (2016) and Molle, López-Gunn and van Steenbergen (2018).

In addition to the scarcity of information about groundwater and aquifers in Brazil (CONICELLI; HIRATA, 2017), the country lacks investigations into how Water Law has embodied such mechanisms (primarily for groundwater) or how states have regulated and implemented them. Moreover, the law's importance to water users and the relationship between groundwater, soil, and environmental demands normative analysis that extends beyond water policy to embody other correlated policies (VILLAR, 2016).

The implementation and fulfillment of such laws face several challenges that exceed the limits of legal provision: a) the non-availability of the means to fulfill the norms (equipment, budget, human resources, incentives, and training, among others); b) the lack of enforcement and sanction caused by the social culture of violation and the states' failure in inspecting large areas presenting thousands of dispersed wells; c) fraud,

bribe, corruption, and selective law enforcement; d) the adulteration of water meters; e) political pressure brought by users; f) the lack of political will motivated by private interests, conflicts with other management organs, consolidated powers and political patronage, bureaucratic issues and inter-sectoral contradictions; or yet g) optimism regarding groundwater supply while underestimating the demand (MOLE; CLOSAS, 2019).

Federal legislation as the basis to develop a state groundwater governance indicator

Legal provisions are characteristic products of human civilization (BOBBIO, 1992). Accordingly, legal rules extend beyond the legal texts because they represent a social manifestation that has sought to coercively control behaviors to reach a given goal (GARBACCIO; PRIEUR; DENNY, 2018). Their shape, interpretation, and application give rise to power games and social struggles (BOBBIO, 1992). Despite the importance of laws in influencing human behaviors and institutions, there is a lack of instruments to assess their effectiveness (MEKOUAR; PRIEUR, 2019).

Governmental reports do not present legal indicators assessing the reach and applicability of laws and regulations. Instead, they are limited to citing these norms without mentioning the imposed obligations or their levels of application. Such a gap has caused managers and public opinion to underestimate or deny the importance and usefulness of law. The literature has acknowledged this problem and the methodological difficulties in overcoming it (MEKOUAR; PRIEUR, 2019; PRIEUR, 2017).

Legal indicators have contributed to assessing the performance of specific components in legal systems by analyzing the following aspects of the norms: a) existence; b) validity; c) enactment; d) invocability; e) awareness of their existence; f) substance; g) progress or regress; h) content accuracy; i) administrative control; j) jurisdictional control; l) prediction of penalties; and m) application of sanctions (PRIEUR, 2017).

Based on these analyses, the following is possible: a) demonstrating the role of law in public policies; b) providing information on law enforcement and pursuing reforms; c) drawing attention to public authorities and societies to the limitations of law; d) allowing society and the public to be informed about the use of law as a critical element in a policy's success or failure; e) creating public awareness about law enforcement; and f) conducting studies with legal and scientific indicators to assess public policies (PRIEUR, 2017; FAO 2016).

Creating legal indicators specific to groundwater would help provide general information about the situation, trend, and features of state public policies on the topic. Therefore, some studies at the international (FOSTER *et al.*, 2010; PIETERSEN *et al.*, 2012; MUMMA *et al.*, 2011; GARDUÑO *et al.*, 2011) and national levels (BOHN; GOETTEN; PRIMO, 2014; GOETTEN, 2015; RAMOS, 2017) sought to determine whether the law has embodied fundamental aspects for groundwater management processes, including environmental licensing, basin plans, water permits, and charging fees.

The development of indicators based on the Brazilian national law and its regulations (decrees and resolutions by the National Water Resources Council and the National Environment Council) would demonstrate the national water governance standards and the management mechanisms or strategies made available to the several states. Moreover, by choosing the Brazilian law, it would be possible to perform analyses focused on uniform aspects endorsed by legal norms that are bound to all states; if not observed, this process may lead to liability.

According to Fernandes (2019), all Federation Units have water resource policies; however, only 12 states enacted laws specific for groundwater: São Paulo, Minas Gerais, Santa Catarina, Rio Grande do Sul, Distrito Federal, Goiás, Mato Grosso, Mato Grosso do Sul, Alagoas, Pernambuco, Maranhão, and Pará. The author stressed the need to regulate groundwater in the other Federation Units. The act of identifying these general or specific state norms represents an advance in overall knowledge; nevertheless, it is critical to analyze how these state norms included and applied the national norms and their mandatory management mechanisms.

The structure of the Groundwater Governance Evaluation System (SAGAS)

The first step toward creating a legal indicator was analyzing the federal water legislation. In addition to FC/88, the following laws and regulations were assessed: law 9.433/1997 (National Water Resources Law), Decree n. 10.000/2019 (it regulates the National Council of Water Resources—CNRH, acronym in Portuguese); CNRH Resolution n. 5/2000 (Basin Committees); n. 15/2001 (General guidelines on groundwater management); n. 22/2002 (Guidelines for the insertion of groundwater in water resource plans); n. 76/2007 (Integration between groundwater extraction and mineral waters); n. 91/2008 (Classification of groundwater bodies according to their use); n. 92/2008 (General criteria and procedures for groundwater protection and conservation); n. 107/2010 (National integrated qualitative and quantitative groundwater monitoring network); 126/2011 (Guidelines for water resource users' registration and integration of databases); and n. 153/2013 (Criteria and guidelines for artificial recharge). The following documents were also used: National Council on the Environment—CONAMA (acronym in Portuguese) Resolution n. 237/1997 (Environmental Licensing); n. 396/2008 (classification of groundwater bodies) and n. 420/2009 (Criteria and values concerning soil quality and the management of contaminated areas)[2].

Because groundwater management is directly linked to soil use, the environment, and policies that regulate water users' activity, the following legal provisions were incorporated into the analysis: law n. 4.504/1964 (Land Statute), Complementary law (CL) n. 140/2011; law n. 6.938/1981 (Environmental Policy); law n. 8.171/1991 (Agricultural Policy), law n. 11.445/2007 (Sanitation Policy); law n. 12.187/2009 (Climate

2 - The use of CNRH Resolution was based on its capacity of setting complementary guidelines to the implementation of law n. 9.433/97 and of its instruments (art. 35), whereas CONAMA Resolutions powers are described in art. 6, II, § 1 and 8, VII, of law n. 6.938/81 and in art. 10 of law n. 9.433/97.

Change Policy); law n. 12.305/2010 (Solid Waste Policy); law n. 12.527/2011 (Access to information); law n. 12.651/2012 (new Forest Code); law n. 12.787/2013 (Irrigation Policy), and Decree n. 4.297/2002 (Economic Ecological Zoning—also known as ZEE).

Although these laws were conceived as sectoral structures marked by specific management principles, objectives, institutional arrangements, and instruments, their implementation should be integrated. They attributed competencies to the three administrative entities in the Federation, which requires a clear vision over the responsibilities of each entity and institutional cooperation to implement the policies discussed above. Because the research focuses on states, obligations under municipalities' competence were not included, including cases related to land use and occupation instruments (law n. 10.257/2001) or the provision of sanitation services (law n. 11.445/2007). Obligations related to polluting activities are shown in the environmental axis.

Criteria set for the Groundwater Governance Evaluation System (SAGAS) were established based on legal obligations identified in national public policies. Its visual structure was based on the checklist developed by Foster et al. (2010), who divided governance into four dimensions: technique, operational, legal, institutional, and cross-sector policy coordination. SAGAS criteria are exclusively substantiated by legal obligations found in the national law and its regulations (decrees and CNRH or CONAMA resolutions). However, the literature provides different management strategies that do not possess the general, abstract, or binding characteristics of legal norms (PRIEUR, 2017). Therefore, all legal obligations were considered equivalent as they needed to be fulfilled.

SAGAS is divided into columns (Table 1); the first column shows the four dimensions; the second and third columns present the numbering and the corresponding legal indicator; in the fourth to the seventh columns, one finds the application variables and their scores; the eighth column contains the fundamentals that ground the answers. In this case, the legal fundamentals column explained the federal obligations' criteria; however, when the checklist is applied to the states, this field must support the adopted responses and scores.

There are two sets of answers in the application variables, to which it is possible assigning a single score that ranges from 0 to 3. The grades are scored as follows: grade "zero" when the criterion is classified as "Nonexistent" (NE) or "Without legal Provision" (WP) in the state legislation; "one" in cases where there is "Legal Provision" (LP); "two" if there is "Legal Regulation" (LR)[3] or if it is "Under Elaboration" (UE)[4]; and "three" if it is "Implemented" (IP). In the subordinate criteria, the evaluation entails attributing a negative (No) or positive (Yes) answer. Score "zero" is the negative answer, and "one" is the positive answer. If the primary criterion is "NE" or "WP," it means a negative answer to subordinate criteria; however, if the primary criterion is classified as "UE," but if there

3 - LR criterion is adopted in cases that regulation is the very core of management mechanisms implementation

4 - EU criterion is used in mechanisms with a complex implementation process that depends on technical studies, actors' participation or whose operationalization demands territorial zoning.

are already implemented practical cases, it is possible to use them as parameters to assess answers given to subordinate criteria.

There are 48 primary indicators and 25 subordinate indicators that comprise a maximum score of 169 points, divided into 144 points for principal and 25 points for subordinate indicators (Table 1). The primary indicators correspond to the legislation's fundamental obligations, whereas the subordinate ones concern the aspects or procedures that should be observed to fulfill the primary indicators. Subordinate indicators maintain the number of the primary indicator, which is followed by a letter, in alphabetical order.

SAGAS' structure is divided into four dimensions, as follows: a) technical—11 primary indicators (33 points); b) Operational-legal—13 primary indicators (39 points) and three subordinate indicators (3 points); c) Institutional-Legal—seven primary indicators (21 points) and eight subordinate indicators (8 points); d) Political Cross-sectoral Coordination—17 primary indicators (51 points) and 14 subordinate ones (14 points), which are subdivided into three axes: environment (eight primary and three subordinate indicators); sanitation (three primary and seven subordinate indicators); and agricultural (six primary and four subordinate indicators).

Even if only the water resource legislation is considered, it is possible to observe a specific degree of autonomy among the technical, operational-legal, and institutional-legal dimensions. For example, technical studies do not ensure or set the conditions for operationalizing instruments found in the operational-legal dimension. In parallel, the operationalization of these instruments can take place without previous studies in the technical dimension. This is the case for groundwater use permits granted in river basins without in-depth studies about aquifer recharge or availability.

Table 1 – Proposition for a Groundwater Governance Evaluation System based on the Legislation

	N.	Criterion	Legal context				Legal Fundamentals
			NE	LP	UE	IP	
Technical	1	Studies to define recharge areas	0	1	2	3	Art. 2, I, of Res. CNRH 92/2008.
	2	Studies to set aquifers' protection zones	0	1	2	3	Art. 2, I, of Res. CNRH 92/2008.
	3	Studies about aquifers' vulnerability to pollution	0	1	2	3	Arts. 2, II, & art. 3º of Res. CNRH 92/2008
	4	Studies to set wells protection perimeters	0	1	2	3	Art. 2, III, of Res. CNRH 92/2008
	5	GW availability diagnosis	0	1	2	3	Art. 2, II, of Res. CNRH 92/2008
	6	GW demand diagnosis	0	1	2	3	Art. 2, II, of Res. CNRH 92/2008
	7	GW quality monitoring network	0	1	2	3	Art. 10 of Res. CNRH 92/2008
	8	GW quantity monitoring network	0	1	2	3	Art. 10 of Res. CNRH 92/2008
	9	GW quality report	0	1	2	3	Arts. 13 & 33 of Res. CONAMA 396/2008
	10	GW users' registry	0	1	2	3	Art. 4, II, of Res. CNRH 91/2008
	11	GW contamination source registry	0	1	2	3	Art. 4, III, of Res. CNRH 91/2008

Operational- legal	12	State Water Resources Plan (SWRP)	0	1	2	3	Arts. 5, I, & 8 of FL 9.433/1997
	12a	SWRP with GW management guidelines	No	0	Yes	1	Art. 5, I, & art. 8 of FL 9.433/1997; Arts. 2 & 3 of Res. CNRH 92/2008
	13	Basin Plan	0	1	2	3	Art. 5, I, and art. 8 of FL 9.433/1997
	14	Classification of GW bodies according to use	0	1	2	3	Art. 5, II, and arts. 9 and 10 of FL 9.433/1997. Res. CONAMA 396/2008
			WP	LP	LR	IP	
	15	Permits to use GW	0	1	2	3	Arts. 5, III, & 11 to 18 of FL 9.433/1997
	15a	Campaigns to promote wells' regulation	No	0	Yes	1	Art. 37 of FC/88
	16	Charging fees for GW use	0	1	2	3	Arts. 5, IV, & 19 to 22 of FL 9.433/1997
	17	GW information system	0	1	2	3	Arts. 5, VI, & 25 to 27 of FL 9.433/1997
	17a	The system has a friendly online platform for society's consultations	No	0	Yes	1	Art. 3, II, of FL 12.527/2011
	18	Aquifers' protection areas	0	1	2	3	Art. 20 of Res. CONAMA 396/2008
	19	GW use restriction and control areas	0	1	2	3	Art. 4 of Res. CNRH 92/2008
	20	Wells' protection perimeter	0	1	2	3	Art. 20 of Res. CONAMA 396/2008
	21	Procedures for closing unproductive wells that are abandoned or whose operation causes harm to GW.	0	1	2	3	Art. 7 of Res. CNRH 92/2008
	22	Procedure to conduct the artificial aquifer recharge	0	1	2	3	Res. CNRH 153/2013
	23	Sanctions for non-compliance with the GW norms	0	1	2	3	Art. 49 of FL 9.433/1997
	24	Procedure to share information between the water resources organ and the mineral resources organ	0	1	2	3	Art. 3 of Res. CNRH 76/2007
			NE	LP	UE	IP	

Institutional-legal	25	State System of Water Resource Management (SSWRM)	0	1	2	3	Arts. 30 & 33 of FL 9433/1997
	25a	GW training programs conducted by SSWRM	No	0	Yes	1	art. 32, I, of FL 9.433/1997
	26	State Council of Water Resources (SCWR)	0	1	2	3	Art. 33, II, of FL 9.433/1997
	26a	SCWR has a technical group for GW management	No	0	Yes	1	Art. 9 of FD 10.000/2019
	27	Basin Committees	0	1	2	3	Arts. 33, III, & 37 to 40 of FL 9.433/1997
	27a	Municipalities' participation in basin committees	No	0	Yes	1	Art. 39, III, of FL 9.433/1997
	27b	Participation of executive State, Federal District and municipalities' powers limited to ½ of the members	No	0	Yes	1	Art. 39, § 1, of FL 9.433/1997
	27c	Users' participation in the basin committees	No	0	Yes	1	Art. 39, IV of FL 9.433/1997
	27d	Users' hold 40% of the total of votes	No	0	Yes	1	Art. 8, III, of Res. CNRH 5/2000
	27e	Civil society's participation in the basin committees	No	0	Yes	1	Art. 39, V, of FL 9.433/1997
	27f	Civil society holds 20% of the total of votes	No	0	Yes	1	Art. 8, II, of Res. CNRH 5/2000
	28	State agency responsive to granting GW permits use	0	1	2	3	Arts. 33, IV, & 41 to 44 of FL 9.433/1997
	29	Water agencies	0	1	2	3	Arts. 33, V, & 41 to 44 of FL 9.433/1997
	30	State Water Resources Fund	0	1	2	3	Art. 19, III, & art. 22 of FL 9.433/1997
	31	State Environment System	0	1	2	3	Art. 6 of FL 6.938/1981
			NE	LP	LR	IP	
Political cross-sectoral coordination Environment	32	Environmental licensing for potentially GW polluting activities	0	1	2	3	Arts. 23, VI, & 24, VI of FC/88; arts. 5, 6 & 9, IV, of FL 6.938/1981; Res. CONAMA 237/1997
	33	Well drilling license or administrative authorization	0	1	2	3	Res. CONAMA 237/1997; art. 6 of Res. CNRH 92/2008
	34	State Environment Information System	0	1	2	3	Art. 8, VII, of CL 140/2011
	34a	The system has a friendly online platform for society's consultations	No	0	Yes	1	Art. 3 of FC 12527/2011
	35	Procedure defined by the state to manage contaminated areas	0	1	2	3	Art. 23 of Res. CONAMA 420/2009
	36	Report about the contaminated areas published in institutional portals of the environmental organ	0	1	2	3	Art. 38 of Res. CONAMA 420/2009
	37	Financing lines to remediate contaminated areas	0	1	2	3	Art. 42, VI, of FL 12.305/2010
			NE	LP	UE	IP	
	38	State ecological economic zoning (EEZ))	0	1	2	3	Art. 9, II, of FL 6.938/1981; Art. 2 of FD 4.297/2002; Art. 8º, IX of CL 140/2011
	38a	GW as EZZ component	No	0	Yes	1	Art. 22 of Res. CONAMA 396/2008
	39	State Climate Change Plan (SCCP)	0	1	2	3	Arts. 5, V, & art. 6, I, da FL 12.187/2009
	39a	SCCP includes guidelines related to water security	No	0	Yes	1	Art. 6, XII, of FL 12.187/2009

Political cross-sectoral coordination Sanitation	40	State Basic Sanitation Plan	0	1	2	3	Art. 19 of FL 11.445/2007
	40a	Goals for the universalization of water access	No	0	Yes	1	Art. 2 of FL 11.445/2007
	40b	Goals for the universalization of sewage access	No	0	Yes	1	Art. 2 of FL11.445/2007
	40c	Goals for sewage treatment	No	0	Yes	1	Art. 2 of FL 11.445/2007
	40d	Specific measurement for GW	No	0	Yes	1	Arts. 2, XII of FL 11.445/2007
	41	State Solid Waste Plan	0	1	2	3	Art. 14, II, of FL 12.305/2010
	41a	Actions to eliminate and recover dumps	No	0	Yes	1	Art. 17, V, of FL 12.305/2010
	41b	Identification of zones favorable for the location of solid waste treatment units or for hazardous waste	No	0	Yes	1	Art. 17, XI, a, of FL 12.305/2010
			NE	LP	LR	IP	
	42	State Information System about Sanitation Services	0	1	2	3	Art. 9, VII, of FL 11.445/2007
	42a	The system has a friendly online platform for society's consultations	No	0	Yes	1	Art. 3 of FL 12527/2011
Political cross-sectoral coordination Agriculture	43	Program for offspring recovery	0	1	2	3	Art. 19, VII, of FL 8.171/1991 & art. 41, I, d, § 5 of FL 12.651/2012
	44	Program for the proper management of animal waste	0	1	2	3	Art. 19, VII, of Law 8.171/1991
	45	State program for Environmental Regularization	0	1	2	3	Art. 59 of FL 12.651/2012
	46	State information system about irrigation	0	1	2	3	Arts. 5, II, & 9 of FL 12.787/2013
	46a	The system has a friendly online platform for society's consultations	No	0	Yes	1	Art. 3 of FL 12527/2011
			NE	LR	UE	IP	
	47	State Irrigation Plan (SIP)	0	1	2	3	Art. 5, I, & 6, § 2 and 3 of FL 12.787/2013
	47a	SIP includes GW availability for irrigation	No	0	Yes	1	Art. 6, I, of FL 12.787/2013
	47b	SIP establishes hierarchy between regions for GW irrigated agricultural projects.	No	0	Yes	1	Art. 6, II, of FL 12.787/2013
	48	Agroecological zoning (AZ)	0	1	2	3	Art. 19, III, of FL 8.171/1991
	48a	GW resources included in AZ	No	0	Yes	1	Art. 19, II & III, of FL 8.171/1991

Notes: GW – Groundwater; FL –Federal Law; FD – Federal Decree; CL– Complementary Law; Res. – Resolution.

Source: Foster et al. (2010), Federal Constitution (1988), Federal law n. 6.938/1981, Federal law n. 8.171/1991, Federal law n. 9.433/1997, CONAMA Res. n. 237/1997, CNRH Res.n. 5/2000, Federal Decree n. 4.297/2002, CNRH Res. n. 76/2007, Federal law n. 11.445/2007, CNRH Res.n. 91/2008, CNRH Res. n. 92/2008, CONAMA Res. n. 396/2008, CONAMA Res. n. 420/2009, Federal law n. 12.305/2010, Federal law n. 12.527/2011, Complementary law 140/2011, Federal law n. 12.651/2012, Federal law n. 12.787/2013, and Federal Decree n. 10.000/2019.

Discussions about the application of SAGAS performed with experts showed that scoring some criteria could be doubtful, and it demanded the elaboration of Table 2, which provides specific instructions.

Table 2 – Specific instructions for criteria application

Criterion	Specific application instructions
1 to 11	Academic or private studies will only be considered if they are officially adopted by the Public Administration.
12a	The answer "Yes" demands specific guidelines for GW management. The mere mentioning or diagnosis imposes option "No".
13 and 14	It is a basic management instrument, that must be considered "IP" if it is elaborated to all state basins. If its presence is partial, one must check option "UE".
14	The mere mention about classification of waterbodies according to their use without specification to GW, imposes option "NE".
15a	Campaigns must be promoted by SSWRM entities.
16, 18, 19 and 22	To be taken as "IP", the implementation in a single basin is enough.
17a, 34a, 42a and 46a	The answer will be negative in case any of these criteria is missing: a) information system available in an open website; b) access to data just by clicking in links, without messages reporting errors or content unavailability; and c) information available without the need of formal request to the organ.
18, 19 and 20	Category "LR" demands determining the organ responsible for implementing the instrument, as well the definition of its procedure and the applicable restrictions linked to water, and soils use. Choose "LP" in case the law just defines the instrument and provides vague guidelines
24	Classifying it as "WP" if law limits data transfer obligations to a single organ. CNRH Res. 76/2007 demands sharing; thus, data exchange should occur between water and mineral resource organs.
25	Option "IP" requires the following institutions' functioning: SCWR; a state organ responsible for water management; and at least one operational Basin Committee.
25a	Criteria are: promoting training by entities from SSWRM; outspreading information in the SSWRM communication channels; and the existence of a training program, rather than occasional events.
27	Classification "IP" demands Basin Committees functioning in all the state territory. Otherwise, it must be classified as "UE", since this entity is the very basis of water management.
29	Option "IP" demands at least one State Water Agency or delegating entity, because their creation is not mandatory (art. 43 of FL n. 9.433/1997).
38 and 48	The answer must be modulated based on the State Law. If it demands EEZ or AZ to be applied in the whole state, this criterion will be taken as "IP" only if the condition is met. Otherwise, it can only be implemented in one region.

Source: developed by the authors in partnership with invited experts.

Scoring grades lower than three evidence non-compliance with legal obligations, and it demands corrective actions or possible reflection about its adequacy to governance. The maximum score shows that the indicator was applied, although it is not intended to determine its effectiveness or efficacy degree. This is so because this assessment is only possible in a qualitative research context that extends beyond the legal aspects of the indicators (PRIEUR, 2017).

It was determined to create classification categories regarding scores obtained in the global context and in each dimension to visualize results. This type of strategy is used in technical indicators to assess aquifer vulnerability toward contaminant loads, as in the case of the *Groundwater Overall Depth* (GOD) and *Pollutant Origin, Surcharge* (POSH) methods (FOSTER; HIRATA, 1988; FOSTER *et a*l., 2002).

Because the present study is qualitative research focused on assessing the general panorama of criteria situation—without investigating the quality of their implementation—the authors opted only to create three classification intervals of state governance based on quartiles. If states' results are in the upper quartile, with a total score or dimension higher than (or equal to) 75%, the performance is good; if the score is in the upper median quartile, i.e., if it is higher than (or equal to) 50%, the performance is moderate; if the score is in the lower median quartile or the first quartile, i.e., it is lower than 50%, performance is low. Central trend distribution (higher than or equal to 50%) is expected because SAGAS criteria derive from obligations imposed to states by policies created in the 1990s and 2000s.

This classification must be applied to each dimension's global and specific scores and axis. The specific application in dimensions is relevant because it reveals governance's weakest points. When the global or the dimensions' scores are equal to or greater than 75%, one can observe a consistent effort to build a favorable environment for groundwater governance by respecting national guidelines. Of course, there are no guarantees that these actions are sufficient; however, one can infer political will to accomplish good governance and instruments and institutions capable of implementing it, even if adjustments are required.

By contrast, if the score is lower than 75% but equal to (or higher than) 50%, one can understand that the state's performance is average. The state's commitment to governance is questionable; however, it is in the process of implementing institutions and water instruments needed to promote governance, although it is below expectations. If the score is lower than 50%, the state is considered to have low performance, with severe deficiency in implementing legal obligations, leading to an inadequate water governance environment.

Final considerations

The Brazilian federal legislation has structured a comprehensive proposal for state groundwater management, encompassing direct and indirect mechanisms internationally

acknowledged as beneficial for water resources. As a result, a basic standard for aquifers' management has been established, and it included: a) guidelines for studies that must be performed; b) the management instruments to be applied; and c) the structure and competencies of both institutions and federal entities.

States embody the national water governance pact and promote groundwater control and management in the Brazilian legal framework. However, the national water law restricts their autonomy, limiting the adoption of measures that grant users a leading role, as advocated in the literature (Figure 1). This is the case for strategies such as community or well users' management mechanisms or even the distribution of water quotas between one entity and another. Another finding is that, although the literature highlights a lack of technical studies about groundwater, the national legislation assigns the states the duty to carry out such studies.

SAGAS is an effort to generate a legal indicator that gathers comparable and systematized data regarding the environment enabling governance based on its legal structure and implementation level. The systematization of 48 primary and 25 subordinate indicators highlights a robust federal normative framework whose operationalization depends on the states. The scarce literature on the actions of states indicates weaknesses related to laws and their enforcement; however, the actual dimension of the problem remains unknown. For example, it remains unclear which existing federal obligations are foreseen, regulated, or implemented by the states.

In constructing SAGAS, it was possible to identify the primary legal obligations that form the National Groundwater Governance Pact (Table 1). Its application would enable assessing the reception and implementation level of such obligations. It would help assess management weaknesses and establish targets focused on sensitive areas directly related to water policies or correlated areas (sanitation, agriculture, and environment). Furthermore, one encourages management transparency and social control by demonstrating such weaknesses.

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SciELO

Governança das Águas Subterrâneas e a Construção de Indicadores Jurídicos para os Estados Brasileiros

Pilar Carolina Villar
Ricardo Hirata

Resumo: A Constituição Federal de 1988 atribuiu aos Estados e ao Distrito Federal um papel de protagonismo na governança das águas subterrâneas, contudo, faltam estudos que avaliem a forma como esses entes conduzem o processo na perspectiva das políticas públicas federais. O objetivo deste artigo é identificar as obrigações jurídicas federais relacionadas à governança dessas águas e construir uma ferramenta que permita avaliar se elas foram incorporadas e aplicadas pelos Estados. A metodologia utilizada foi a análise documental e a realização de entrevistas. A legislação federal garantiu um standard de mecanismos para a gestão estadual, a partir dos quais foi possível estruturar o Sistema de Avaliação de Governança das Águas Subterrâneas (SAGAS), composto por 48 indicadores principais e 25 subordinados. O SAGAS é um esforço metodológico que visa criar um indicador jurídico que gere dados comparáveis e sistematizados sobre esse ambiente de governança estadual, permitindo identificar as fragilidades da gestão.

Palavras-chave: Governança das águas subterrâneas; indicadores jurídicos; legislação federal, Estados brasileiros.

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SciELO

Gobernanza de las Aguas Subterráneas y la Construcción de Indicadores Jurídicos para los Estados Brasileños

FraPilar Carolina Villar
Ricardo Hirata

Resumen: La Constitución Federal de 1988 asignó a los Estados y al Distrito Federal un rol protagónico en la gobernanza del agua subterránea, sin embargo, faltan estudios que evalúen como estas entidades conducen ese proceso desde la perspectiva de las políticas federales. Este artículo pretende identificar las obligaciones jurídicas federales relacionadas con la gobernanza de estas aguas y construir una herramienta que permita evaluar si han sido incorporadas y aplicadas por los Estados. La metodología utilizada fue el análisis de documentos y entrevistas. La legislación federal garantizó un estándar de mecanismos de gestión estatal, a partir de los cuales se estructuro el Sistema de Evaluación de la Gobernanza de Aguas Subterráneas (SAGAS), compuesto por 48 indicadores principales y 25 subordinados. SAGAS es un esfuerzo metodológico que idealiza un indicador jurídico que genere datos comparables y sistematizados sobre el ambiente de la gobernanza en los Estados, permitiendo identificar las debilidades de la gestión.

Palabras-clave: Gobernanza del agua subterránea; indicadores jurídicos; legislación federal; Estados brasileños.

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